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AUTHOR Tamor, Lynne
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ABSTRACT

Traditionally, studies of beginning reading have focused either on between-subjects' differences or on changes in reading performance characteristics induced by specific training procedures. A third approach to reading is a within-subjects' comparison of individual performance characteristics at varying difficulty levels. The present study investigated the effect of text difficulty level on types of reading errors and the relationship of cognitive style to those effects. Tape recordings were made of elementary school children reading texts at a variety of difficulty levels. Tests were also administered to measure reading achievement and cognitive style. The children's strategies when confronted with difficult material seemed to indicate that a fluent reader switches reading strategies freely to adapt to differing demands of various reading tasks, and that this ability may well be largely a function of general psychological parameters such as cognitive styles. A reading model was constructed, within the framework of Pascual-Leone's and Rumelhart's theories of cognition, which incorporates as an important factor the ability to shift reading strategies. At least three cognitive styles can be identified: adaptive flexibility, impulsivity-reflection, and field dependence-independence. This type of research places reading within a broad cognitive processing framework and may provide curriculum developers and teachers with a more complete understanding of the process they are trying to teach. (Author/AM)

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ORAL READING: Individual Responses to Increasing Text Difficulty as a Function of General Cognitive Parameters[1]

Lynne Tamor
High/Scope Educational Research Foundation

The ideas I will present in this paper are an offshoot of a large project on the psychology of reading in which I attempted to develop a process model of reading which could be integrated into a general process-theory of cognitive. In order to test certain predictions generated by that reading model, I collected tape recordings of elementary school children reading texts at a variety of difficulty levels. At the same time, I used the Wide Range Achievement Test vocabulary list to obtain an independent measure of reading achievement and also administered tests of four different cognitive styles. What was unusual about this project was the attempt to produce a comprehensive theory which could account for results already reported in the literature and generate a wide range of hypotheses about the relationships between reading performance and achievement variables and underlying cognitive parameters.

In the course of collecting data, I observed a phenomenon to which I had seen no references in the literature and yet which seemed extremely important. The texts I was having the children read were the paragraphs from Form A of the Gilmore Oral Reading Test. The texts range from the first to the tenth grade level; and as the grade levels increase, the difficulty of the syntax and vocabulary and the level of conceptual abstraction all increase simultaneously. Children seemed to react to these increases in difficulty in two distinct ways.

Some children slowed down considerably and began reading very "carefully," sounding out unfamiliar words and making few mistakes on words which were in their everyday reading vocabularies. Such children often said that they had a general idea of what the text was about, even though a lot of the words were completely unfamiliar. (A side note is that many of the words were "unfamiliar" only because the children mispronounced them. A prime example was the word psychology, which was almost universally misread as "physiology", "physicology", "physsology", or some similar pseudoword. When told later that the word was psychology, many children expressed a sense of revelation.)

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The second set of children reacted quite differently to the increase in difficulty, seeming abruptly to "fall apart." In addition to making errors on the difficult vocabulary items, they seemed unable to read familiar words and began to omit words, particularly articles and prepositions, and to make many substitution errors as well as pronunciation errors.

Observing this phenomenon reminded me of a similar situation which had repeatedly drawn my attention while I was teaching a graduate course in statistical methods. Since the course was one required of doctoral students at Berkeley, it seemed reasonable to assume that all the students could read moderately well. The textbook used in the course was technical, but it avoided mathematical jargon, and while dense, was relatively readable. Yet many students in every class would maintain that the book was absolutely useless to them--they could not read it. This at the same time that some of their classmates were complaining that much of the material covered in class was dealt with at least as effectively in the text.

I had also observed the reverse phenomenon in a close friend who is an extremely well-read scholar in the field of history of technology. He reads almost constantly, usually highly technical books, often in archaic language. Naturally, he reads such books quite slowly, but he also remembers their contents and integrates their ideas into his own knowledge structures. He claims, however, that as much as he is interested in literature, he cannot read non-technical prose because it takes him too long. Indeed, he reads current best sellers at exactly the same pace, and apparently in the same way, as he reads technical analyses of renaissance scientific thought.

In putting together these observations of children and adults, it seemed that an important factor in being a "good" reader is the ability to shift reading strategies in order to adapt to changing demands of various texts. While I had not originally tried to incorporate this factor into my model of the reading process, I was relieved to find that it had in fact been there all along, although neither I nor anyone else I had talked to had paid much attention to it. The rest of this paper will be concerned with outlining the reading model and translating the observations I have been describing into psychological process terms.

The general cognitive process model within which the reading model was developed is the neo-Piagetian Theory of Constructive Operators developed by Juan Pascual-Leone. The theory is far too complex to describe it (or defend it) in this paper. For now it must suffice to say that the theory is based on the Piagetian notion of the scheme as the basic unit of psychological knowledge. Pascual-Leone provides mechanisms by which the psychological system, consisting of schemes and constructs called scheme-boosters or constructive operators, functions in real time in order to determine human cognitive performance.

Each scheme consists of two parts: a releasing component and an effecting component. When elements in the releasing component are stimulated by external (perceptual) or internal cues, the scheme is activated. Clearly, at any moment, huge numbers of schemes will be activated since even a single cue could stimulate many schemes. The effecting component of a scheme, which can stimulate still other schemes or lead outside the psychological system to produce behavior, can only have an impact if the scheme has applied. Activation is necessary but insufficient--application is crucial. The crux of the theory, then, is the determination of which of many activated schemes in fact will apply and thereby become part of the ongoing cognitive processing. This is accomplished through a principle called Schematic Overdetermination of Performance, usually referred to as SOP by students of the theory.

In general terms, each activated scheme has a weight which is determined jointly by the number of releasing cues which have been stimulated, affective factors, the degree to which the scheme is incorporated into larger knowledge structures, perceptual salience, and mental energy directed toward that particular scheme. Groups of schemes which are non-contradictory and which together have the highest weight will always apply. A crucial point here is that the model does not allow for any randomness or chance factors. If one could actually see all the schemes, all the releasers which are activating schemes, and the strength of the governing parameters (or boosters), then one could predict performance with absolute accuracy. Hence, the key phrase for the whole theory is overdetermination of performance.

A psychologist observing a subject perform might have occasion to describe the subject's performance as "guessing." By the term "guessing" he or she probably would mean that from the psychologist's own viewpoint, the subject acted arbitrarily, perhaps due to inadequate information or knowledge. In fact, the subject might even agree that he or she had been guessing when responding to some question or problem situation. However, the subject's psychological system never "guesses." Performance is determined as a function of all the factors I just ennumerated. These factors all have values which are fixed at any given psychological moment, even if at present we do not know how to discover what some of those values are.

The reason for all this discussion of "guessing" or rather of the lack of guessing in Pascual-Leone's psychological model will become apparent as soon as I mention Kenneth Goodman and his theory of reading. Primary inspiration for my model of reading was drawn from Goodman's work, in which he calls reading a "psycholinguistic guessing game." It seems to me that all available data, and certainly my own data, support Goodman's contention that reading performance is the product of an integration of knowledge derived directly from the print--that is, letters and other graphic symbols, knowledge about language, and general knowledge about the world. How else can one explain why one of my subjects read "mother" instead of "parents" in the sentence, "Bob and Jane now think they will eventually comply with their parents' wishes"? This girl read "mother's wishes" instead of "parents' wishes,"

an error which makes perfect sense but bears little resemblance to the printed text. An error along the same lines was made by a number of children in the sentence, "They are beginning to realize that the mind of man...is a significant study in itself." Instead of "significant," these children all read "scientific."

Goodman maintains that readers use knowledge gathered from both graphic and contextual cues to make a "best guess" as to the actual translation of the graphic symbols into language. If Goodman really means what he says when he calls reading a guessing game, he is confusing the psychologist with the psychological system. Often when we watch children read, they appear to be guessing and in fact, we might say to a child who is having trouble, "Can you guess what that word is?" But the psychological system of that child does not guess--it evaluates the strengths of all activated schemes and scheme-clusters and the strongest schemes prevail. No readers, good or poor, human or mechanical, ever guess because all performance is overdetermined.

I mention mechanical readers as well as human readers because David Rumelhart, working from theories of artificial intelligence, has developed a model of reading which shares many characteristics with mine. It also involves integration of cues from many sources and determines performance through mathematical calculation of weights. I argue elsewhere that while Rumelhart's model is a great step forward from previous models, it does not meet the needs of educators and developmental psychologists. It has no place for affective factors such as motivation and does not allow for modelling the learning-to-read process. The mathematical computations required for processing are not a metaphor, as they are in Pascual-Leone's model, but an actual part of the system. Nonetheless, because Rumelhart's model is simpler than Pascual-Leone's general model, and it is adequate for most of the purposes of this paper, I will use it here.

Rumelhart illustrates his theory using the following situation: the reader is first shown a picture and then shown a printed noun phrase which will refer to some item in that picture. Thus the picture provides a general context for the text which will follow. In most cases of naturally-occurring reading, some general context is established before text processing begins, although that context is rarely as narrowly defined as in the Rumelhart experiment. The noun phrase presented in his paper, and on your handout (which is copied from his paper), was /THE CAR/.

The diagram on the handout represents a partial state of the message center, or central processing area, of the reading system very soon after the phase is presented. In order to fully represent the reading process in Rumelhart's model, it would be necessary to use a series of such diagrams, one set for each psychological moment.

Featural knowledge is taken to be the basic level for processing text. The features processed in this hypothetical example are represented at the bottom of the tree structure, just above the actual text presented. It happens that only the letter /T/ is uniquely determined by the features scanned--for all other feature sets, at least two letters are possible. For example, the /H/ could be an /A/, a /B/, an /E/, or an /F/. Thus, the system's hypothesis that the first letter is /T/ has no competitors at the feature level, but the /H/ hypothesis has at least four. All four will receive some weight from the features which support them. At the letter cluster level, the /H/ hypothesis will receive additional weight since once a /T/ is recognized, there is a high probability that an /H/ will follow. The system also "knows" that in this position, an /E/ is possible, but the other letters are not. All this knowledge is represented in the system as conditional probability statements. For example, the system has an exact value for the probability that a letter is an /H/, given that the preceding letter was a /T/. The conditional probabilities for an /E/ or an /H/ following a /T/ are both high, while the probability is near 0 for /B/ or /F/. At the same time, the reader is expecting a noun phrase, and therefore it is highly probable that the first word is a determiner. This probability is also represented as a specific value within the system. The entire tree structure can in fact be represented as a mesh of conditional probability statements. In the end, the system computes the probabilities associated with the various competing hypotheses and the first word is read as /THE/ because no conflicting hypothesis has a high enough probability to contradict it. This correcting reading is not a guess, even though the featural knowledge on which it was based was insufficient to determine the constituent letters of the word.

Processing of the word /CAR/, on the other hand, could lead to a /CAT/ hypothesis as shown in the diagram. The hypothesis will be blocked, however, since there was no cat in the picture and therefore at some higher level a 0 value will appear in the probability equation for that hypothesis. If both a cat and a car were in the picture, the situation would become more complicated. Possibly a rescanning strategy would be activated if the probabilities of the two hypotheses were nearly equal. On the other hand, differential probabilities due to some bias in the system would result in the reading of /CAT/ or /CAR/ with no real competition from the other word. It is important to realize that even when rescanning occurs, the reader is not necessarily aware of conflict or of a rechecking strategy. Validation of theories such as Rumelhart's and Pascual-Leone's is possible only through modeling or empirical testing of hypotheses generated from the theories, not through introspection or self-monitoring.

Rumelhart differentiates between what he calls direct and indirect evidence for hypotheses. Direct evidence comes from lower down in the tree structure and has a direct line from the featural evidence. All other evidence is called indirect. This distinction is similar to Goodman's graphic-contextual distinction, but is more useful for a real-time processing model, where the definition of context can become ellusive. For example, the evidence for the letter /H/ derived from knowledge about letter-clusters is indirect evidence, or contextual evidence, even though it is knowledge about the graphic representation of English.

At long last, I can return to my stated topic: adapting reading strategies to text difficulty. I hope that you are now convinced, if you weren't already, that the reading process involves balancing information derived from a variety of sources. In addition, it can be influenced by affective states, mental energy, and other cognitive factors I will get to in a minute. For any given text, a balance appropriate for one reader may not be the balance appropriate for another reader. For any given reader, a balance appropriate for one text will not be appropriate for another text.

I suspect that my statistics students who could not read their text book were used to relying heavily on contextual semantic cues in their reading. The statistics text contained many relatively unfamiliar words, was written in an unfamiliar style, and contained many new ideas. Therefore, there were insufficient contextual cues available for reading the text comfortably--an increase in attention to features and graphic context was required. Students who could not read the book were failing to alter the balance, students who succeeded in reading made the necessary adjustments.

The children in my research study had a similar problem. The easier text contained familiar words, simple syntax, and dealt with predictable topics such as the morning before-school routine in a suburban household. The more advanced texts used unfamiliar words, complex syntax, and actually contained new information of a conceptual nature. The children who "fell apart" when the text became difficult were relying heavily on contextual cues. Hypotheses with relatively low probabilities were allowed to apply since they were not blocked by higher level inconsistencies and no hypotheses were supported by much direct evidence. The children who slowed down and began to sound out the unfamiliar words seemed to have "shifted gears" and increased their use of graphic cues to compensate for the loss of contextual cues.

The problem now is to explain the mechanism which determines the graphics-context balance in the first place and those which trigger changes in that balance. While the knowledge structures available to the child may account for part of this phenomenon, I believe that at least three cognitive styles also play a role. These styles are adaptive flexibility, impulsivity-reflection, and field dependence-independence.

The most obviously relevant style is adaptive flexibility which has to do directly with the tendency to abandon previously successful problem-solving strategies in response to changes in outwardly similar tasks. Experience teaches all of us to "stay with what works" and individuals vary in their willingness to abandon strategies which have ceased to work. Some people will continue to attempt to use the same strategy, others will quickly shift. Pascual-Leone explains this difference in terms of a trade-off between strategies boosted by prior experience and those selectively boosted by mental energy. In order to shift strategies, mental energy is required and individuals vary both in their store of mental energy and in their tendencies to use what they have. The theory predicts that readers high in

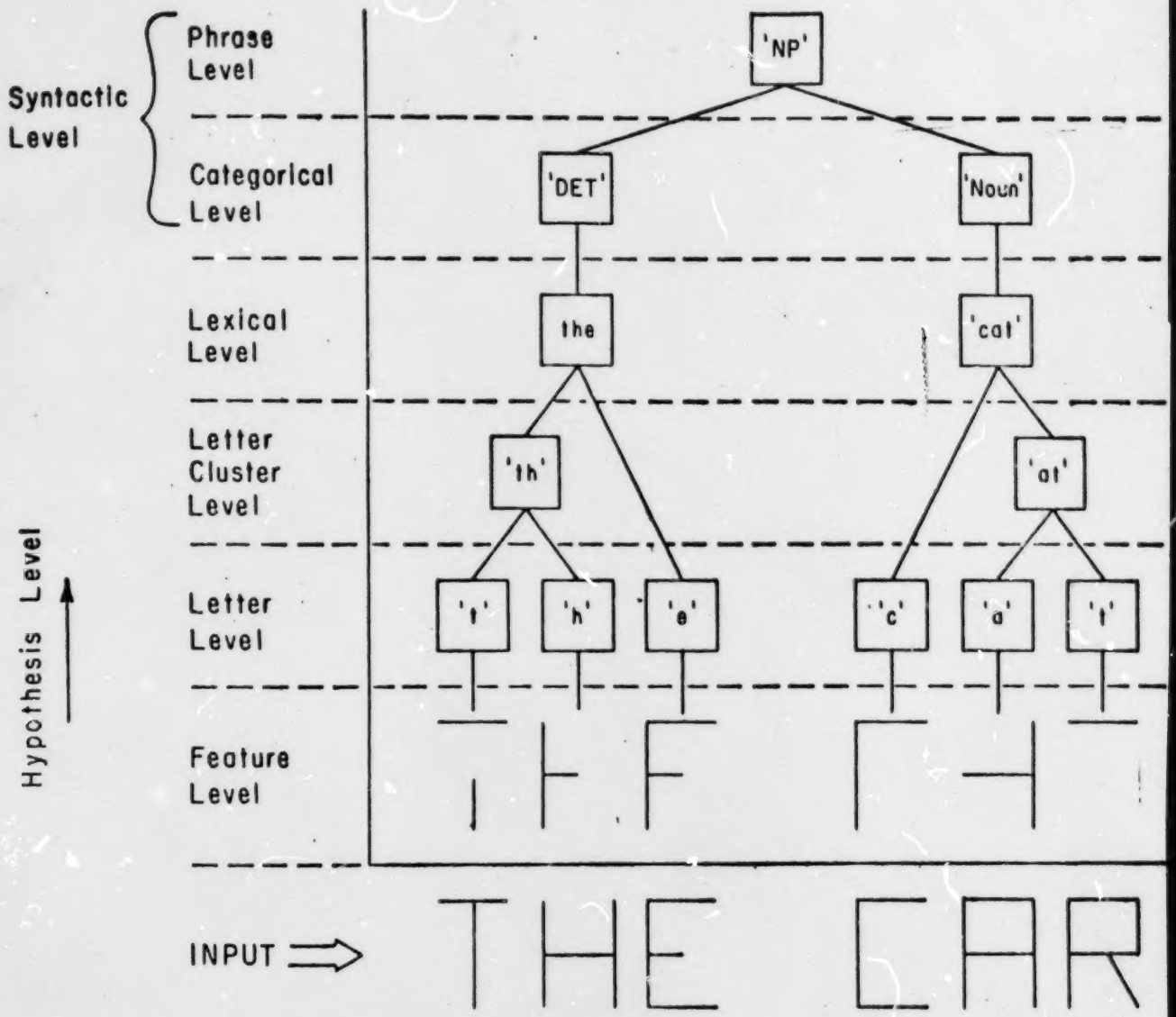
adaptive flexibility will shift strategies in response to changes in text difficulty; readers low in adaptive flexibility will not. Preliminary analysis of my data indicates that such is indeed the case, although problems in measurement make this finding tentative at best.

A second style which logically should influence the tendency to shift reading strategies is impulsivity-reflection. If it is true that reflectives are more concerned than impulsives with evaluation of the quality of their responses, they should be more likely to slow down and increase attention to perceptual cues. It has been shown that reflectives have a greater tendency than impulsives to feature-analyze, precisely the operation which is required when contextual cues prove insufficient.

Impulsivity-reflection overlaps field dependence-independence in the area of feature analysis, as field independents also tend to use this strategy more often than field dependents. In non-perceptual tasks, it has been shown that field independents are more successful in reasoning by analogy and in using broad contexts to help solve problems. Thus one might expect that field dependents would show less response to changes in texts because their repertoire of potentional information sources is smaller than for field independents.

My data has shown, however, that, as predicted by the theory of constructive operators, all three of these styles are interrelated. It is impossible to know, therefore, whether the observed influences of these three styles are separable or whether they represent a single source of variation measured in several ways. At this point, my data analysis procedures are very rough, particularly when judgments of degree of strategy shifting are made. At the same time, I encountered difficulties in using some of the standard style measures with children in the learning-to read age range. Therefore, it was impossible to carry out the sophisticated statistical procedures required to tease apart the precise contributions of each style dimension to the overall pattern of reading performance. Nonetheless, I believe that these methodological problems can be relatively easily overcome and that further research in this area would be of great value both to theoreticians and practicing educators.

A Two-Dimensional Slice of the Message Center*



*Rumelhart, David E. "Toward an Interactive Model of Reading." Center for Human Information Processing, University of California, San Diego, 1976, p. 23.

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